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Draft
Biological Treatment Test Plan

McCormick & Baxter Creosoting Company
Portland Plant
Portland, Oregon

Contract No. 88-97

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Prepared for:
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List of Acronyms

ACL	Alternate concentration limit
AQUIP	Aquifer Investigation Plan
AWQC	Ambient water quality criteria
BOD	Biochemical oxygen demand
BTTP	Biological Treatment Test Plan
COCs	Contaminants of concern
COD	Chemical oxygen demand
DAF	Dissolved air flotation
DEQ	Department of Environmental Quality
DNAPL	Dense nonaqueous phase liquid
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
FS	Feasibility study
FWDA	Former Waste Disposal Area
GAC	Granular activated carbon
gpm	Gallons per minute
IDW	Investigation-derived waste
LNAPL	Light nonaqueous phase liquid
MS/MSD	Matrix spike/matrix spike duplicate
NAPL	Nonaqueous phase liquid
NPDES	National Pollutant Discharge Elimination System
O & M	Operation and maintenance
PACT	Powdered activated carbon treatment
PAH	Polycyclic aromatic hydrocarbon
PCP	Pentachlorophenol
PPE	Personal protective equipment
QA/QC	Quality assurance/quality control
RA	Remedial action
RBC	Rotating biological contactor
RCRA	Resource Conservation and Recovery Act
RI	Remedial investigation
ROD	Record of Decision
TFA	Tank Farm Area
TOC	Total organic carbon
VOC	Volatile organic compounds

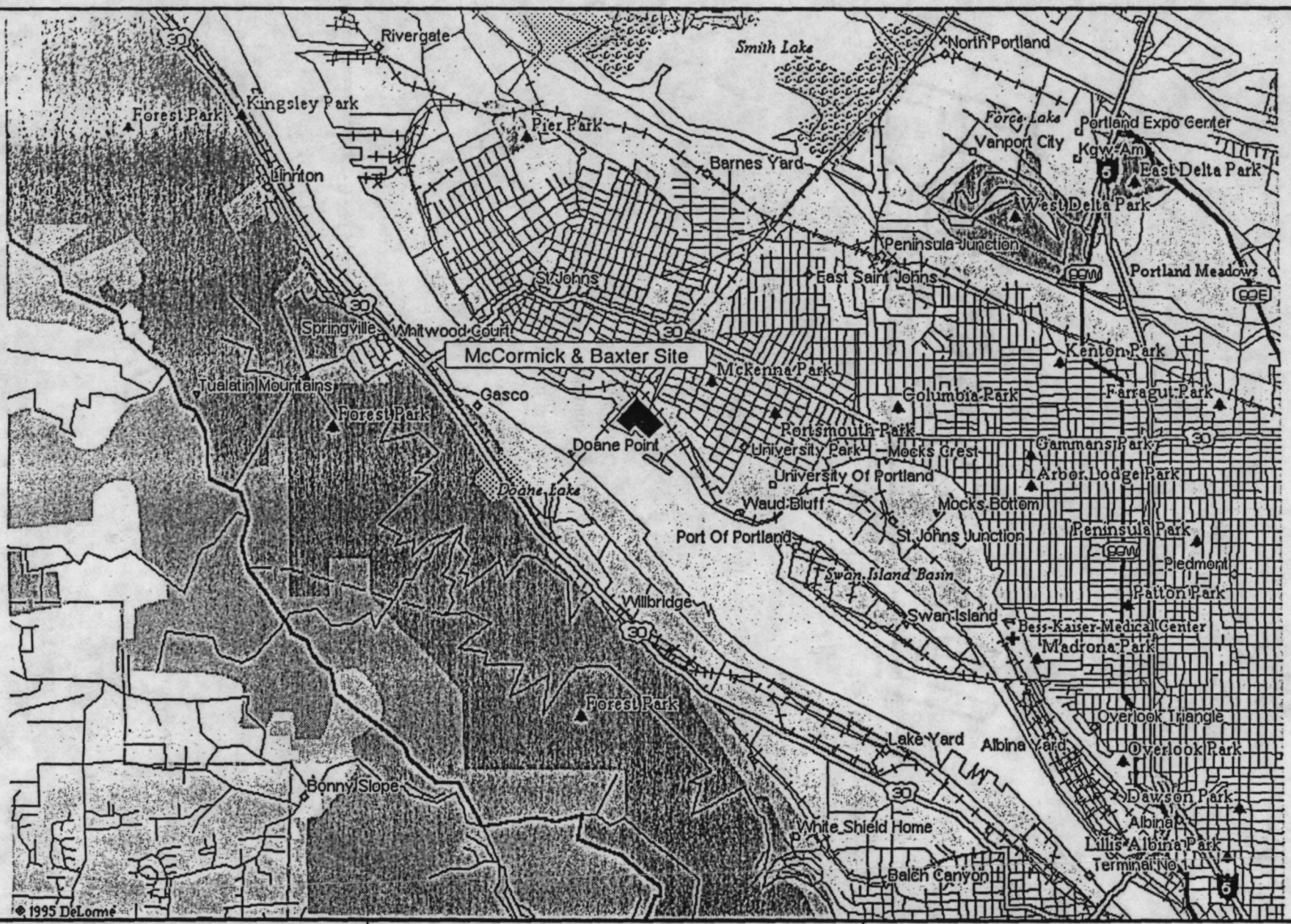
1 Introduction

Ecology and Environment, Inc. (E & E), under contract with the Oregon Department of Environmental quality (DEQ), has prepared this Biological Treatment Test Plan (BTTP) for groundwater remedial action (RA) activities at the McCormick & Baxter Creosoting Company Portland Plant (McCormick & Baxter) site located in Portland, Oregon. The site, a former wood-treating facility, is located along the Willamette River at 6900 Edgewater Street (see Figure 1-1).

This document has been prepared under Task Order No. 88-97-5 and in accordance with the Remedial Action Work Plan dated March 1997 (E & E 1997). This document has been prepared to address nonaqueous phase liquid (NAPL) and contaminated groundwater treatment options as they apply to the final groundwater remedy described in the Record of Decision (ROD) (EPA 1996).

The ROD identified two options for providing treatment of NAPL and groundwater, which is generated as part of implementing the groundwater remedy. The existing pilot treatment system will either be enhanced to increase capacity and automated for continuous operation or replaced with a new system with a capacity of approximately 30 gallons per minute (gpm) and designed for continuous, automated operation. The ROD further noted that biological treatment may be incorporated into the final system to reduce the volume of wastes generated such as sludge and spent activated carbon. E & E presented an evaluation of the existing pilot treatment system in Section 3.2.3 of the RA Work Plan (E & E 1997) that was based on 1.5 years of operation and treatment train analytical data. E & E concluded that this pilot treatment system could not be readily enhanced and automated to attain the final remedial requirements. E & E recommended the design and installation of a system incorporating higher flow capacities, automated operation, and less dependence on activated carbon to achieve the requirements of the ROD. E & E also recommended the investigation of biological treatment to minimize the rate of carbon consumption in the final treatment system.

The purpose of this BTTP is to document E & E's focused evaluation of treatment options and present an approach for investigating the use of biological treatment as a possible component in the final treatment system. Section 2 of this plan present background, establishes project assumptions, identifies the contaminants of concern, and outlines treatment goals for the final



ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

McCORMICK & BAXTER CREOSOTING CO.
PORTLAND, OREGON

FIGURE 1-1

SITE LOCATION MAP

0 .5mi 1 mile
Approximate Scale in Miles

Drawn By:	Date	TDD/Job No.	Dwg. No.
MRE	10-11-96	019020	019020F4

system. Section 3 presents a brief technology overview and evaluation with respect to E & E's site experience and the project requirements. This section also provides the rationale for selection of a biological treatment process to be pilot tested at the site. A description of the proposed toxicity and pilot tests is presented in Section 4. Section 5 contains the laboratory quality assurance objectives, Section 6 details sample custody and handling procedures, and Section 7 outlines instrument and equipment calibration procedures and frequency. A proposed schedule for document deliverables is listed in Section 8, and Section 9 lists all references used in completing this report.

2 Overview

This section provides a general background discussion, describes the current site conditions, outlines the rationale for investigating biological treatment, identifies the contaminants of concern (COCs), defines the treatment requirements for the site, and presents assumptions that were made in the preparation of this document.

2.1 Background and Current Remedial Actions

As discussed in the RA Work Plan (E & E (1997), the groundwater at the McCormick & Baxter site is currently undergoing RA. Current groundwater and NAPL extraction and treatment activities, which began as interim remedial actions during the remedial investigation and feasibility study (RI/FS) stage, are now considered final RAs. The current groundwater RAs consist of the following:

- Enhanced NAPL extraction in the Tank Farm Area (TFA);
- Operation of the pilot water treatment system;
- Manual NAPL extraction; and
- Operation of the automated NAPL extraction and treatment system in the Former Waste Disposal Area (FWDA).

The enhanced NAPL extraction system in the TFA consists of three extraction wells, containing one pump each, that operate on a 5-day-per-week, 8-hour-per-day basis. The extraction pumps in the wells are operated at a flow rate between 2 to 4 gpm. The pumping action is intended to enhance the collection of NAPL by pumping both groundwater and NAPL at low flow rates. The combined groundwater and NAPL extracted from the TFA wells is conveyed to the pilot water treatment system. In general, the combined flow rate from the three wells is 10 gpm. No hydraulic control is attained by this enhanced NAPL extraction action. The pilot water treatment system is located within a large steel building in the center of the site, which had been used as a maintenance shop during former wood-treating operations. This treatment system employs three treatment techniques to treat the groundwater and NAPL that is

generated by the enhanced NAPL extraction system: settling, oil (NAPL)/water separation, and filtration. The combined groundwater and NAPL flows into a 20,000-gallon tank (Tank 1) to allow settling and phase separation. The groundwater and NAPL separates into light nonaqueous phase liquid (LNAPL), water, and dense nonaqueous phase liquid (DNAPL) phases. The settling tank provides gross phase separation of only the lightest and heaviest components of NAPL. A significant quantity of neutral buoyant NAPL and emulsified NAPL remains in suspension with the water in the form of very small droplets. The "water" portion is gravity fed from Tank 1 into a dissolved air floatation (DAF) unit. The DAF separates the NAPL droplets from the water by the addition of flocculent, which coalesces the droplets into larger particles. The DAF unit utilizes recirculation pumps that blend air into the water to form micro bubbles. The flocculated NAPL becomes more buoyant due to the presence of the bubbles and floats to the surface of the DAF. The floating sludge that forms at the surface of the water within the DAF is skimmed off by a rotating skimmer. The sludge collected by the skimmer is placed into a settling tank (Sludge Tank) and the water exits the DAF. The DAF provides oil/water separation and slight reductions in dissolved contaminant concentrations. The final treatment step consists of filtering the water through particulate filters followed by granular activated carbon (GAC) polishing. The GAC removes the dissolved organic contaminants that are not significantly removed by the previous treatment steps. This system is not automated and requires an on-site technician during each day of operation. The system treats water 5 days per week, 8 hours per day, at a flow rate of 10 gpm.

Manual NAPL extraction activities are conducted by the site technician weekly and bi-weekly at wells that typically collect NAPL. The technician uses an oil/water interface probe to determine the location of NAPL within the monitoring well. The technician calculates the volume of the NAPL and lowers a pneumatic bladder pump into the well to the depth at which the NAPL is present. The technician operates the pump until the calculated volume of NAPL is removed or until water is noticed in the discharge. All of the equipment is cleaned and the same procedure is repeated at the next well. The extracted NAPL is placed into the Sludge Tank for storage. This activity is extremely time consuming and labor intensive.

In May 1996, E & E installed an automated NAPL extraction and treatment system in the FWDA to improve the rate of NAPL extraction and to provide additional treatment capacity in this area of the site for subsequent aquifer investigation activities. The FWDA extraction and treatment system consists of four extractions wells equipped with pneumatic bladder pumps, a holding tank, an oil/water separator designed for both LNAPL and DNAPL, particulate filters, and GAC units. The system utilizes level sensors and pressure switches to provide automated, continuous operation. No hydraulic control is achieved by the extraction system in the FWDA.

These RAs only partially address the remedial action objectives (RAOs) for the groundwater remedy in that NAPL is being extracted from the groundwater. The majority of the RAOs are not being attained by the current activities; therefore, enhancement to these RAs are required. The RA Work Plan (E & E 1997) divided the identification, evaluation, and selection of the required enhancements into aquifer-specific and treatment-specific actions. E & E will submit, under separate cover the Aquifer Investigation Plan (AQUIP) to address the aquifer-specific actions. This BTTP addresses the treatment-specific actions.

2.2 Biological Treatment Investigation Rationale

The ROD (EPA 1996) identified two options for providing treatment of NAPL and groundwater that is generated as part of implementing the groundwater remedy. The existing pilot treatment system will either be enhanced to increase capacity and automated for continuous operation or replaced with a new system with a capacity of approximately 30 gpm and designed for continuous, automated operation. The ROD further noted that biological treatment may be incorporated into the final system to reduce the volume of wastes generated, such as sludge and spent activated carbon. E & E presented an evaluation of the existing pilot treatment system in Section 3.2.3 of the RA Work Plan (E & E 1997) that was based on 1.5 years of operation and treatment train analytical data. E & E concluded that the pilot treatment system could not be readily enhanced and automated to attain the final remedial requirements. E & E recommended the design and installation of a system incorporating higher flow capacities, automated operation, and less dependence on activated carbon to achieve the requirements of the ROD. E & E also recommended the investigation of biological treatment to minimize the rate of carbon consumption in the final treatment system.

The purpose of conducting a pilot test of biological treatment is to determine whether it is a technically and economically viable system to treat site contaminants and to obtain engineering data necessary to design the full-scale system. Examples of critical engineering data that will be obtained include flow capacity through reactors, optimum residence time, recirculation rates, air flow rates, nutrient feed rates, inoculation requirements, sludge generation rate and volume, biological treatment efficiencies, optimum operating temperatures, and heating requirements.

2.3 Contaminants of Concern

The primary COCs that are associated with the groundwater at the site are NAPLs, total polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), total arsenic, total chromium, total copper, and total zinc. Hexavalent chromium was also identified as a COC in

the ROD (EPA 1996); however, it occurs primarily when high levels of total chromium are present. Thus, hexavalent chromium is considered a secondary COC. Dioxins and furans also are considered secondary COCs, since they are present in site soil and, based on historic data presented in the ROD, are also present in the groundwater. Dioxins and furans are not highly soluble in water and are relatively immobile compounds. Dioxin and furan compounds are typically present at wood-treating sites that utilized PCP because they are generated in the PCP manufacturing process. As noted in the ROD, treatment of groundwater and attainment of the discharge limit for PCP will result in the treatment of dioxins and furans. The evaluation of the technology and the various biological treatment options presented in Section 3 were based on the primary COCs listed above.

2.4 Treatment System Discharge Requirements

Treated water will either be discharged to the Willamette River, in accordance with the substantive National Pollutant Discharge Elimination System(NPDES) requirements defined in Table 2-1, and/or will be used in testing of enhanced NAPL recovery methods. Discharge limits, which were established by DEQ's Water Quality Source Control Section, are based on a 10-foot mixing zone from the discharge point source in the river. The concentrations were established to meet the ambient water quality criteria (AWQC) at the edge of the mixing zone.

Currently, the pilot and FWDA systems discharge treated water to the Willamette River through Outfalls 2 and 5, respectively. Weekly composite water samples are collected from each outfall for compliance monitoring. The results from each system are combined to obtain the monthly average concentrations.

2.5 Technology Evaluation Assumptions and Criteria

During 1996, E & E collected two treatment train samples from the pilot treatment system to determine the types of contaminants and their concentrations for evaluating the system. The sampling events were separated by 6 months to evaluate possible seasonal changes in the aquifer. The sampling results were summarized and presented in the first and third quarter 1996 quarterly reports (E & E 1996a, 1996b). E & E primarily used these contaminant concentrations during the technology evaluation since the source of the water was the TFA extraction wells. E & E also used the results of the quarterly groundwater monitoring program as a reference. However, the monitoring wells that are sampled as part of the quarterly groundwater monitoring program will most likely not be utilized as extraction wells in the future, since they are located around the perimeter of the site. The contaminant concentrations noted in the quarterly

TABLE 2-1

NPDES DISCHARGE LIMITS
MCCORMICK AND BAXTER CREOSOTING COMPANY
PORTLAND PLANT
PORTLAND, OREGON

Parameter	Monthly Average (µg/L)	Daily Maximum (µg/L)
Flow	--	43,200 gallons/day[a]
Arsenic (total)	80	120
Chromium (VI)[b]	19	28
Chromium (III)	350	500
Copper	20	30
Zinc	190	280
PCP[c]	22	33
Total PAHs[d]	1,700	2,500
pH	6.5 - 8.5 SU	6.5 - 8.5 SU

a Equivalent to 30 gallons per minute over a continuous 24-hour period.
b Hexavalent chromium need not be analyzed if chromium III is below limits for hexavalent chromium.
c DEQ has established a total maximum daily load terachlorodibenzo-p-dioxin (TMDL) and waste load allocation (WLA) for discharges to the Willamette River of 2,3,7,8-tetrachlorodibenzodioxins (TCDD). A 5 µg/day WLA has been established for NPDES discharges from the site, which will be met through compliance with PCP discharge limits.
d Sum of all detected polycyclic aromatic hydrocarbons.

Key:
PCP = Pentachlorophenol
PAH = Polynuclear aromatic hydrocarbons

groundwater monitoring program are consistently less than the results of the treatment train samples.

As part of the technology evaluation, E & E utilized the following criteria to determine which technologies would be most appropriate for pilot testing:

- Ability to efficiently remove the COCs;
- Successful full-scale application at former wood-treating sites;
- No patented or proprietary technologies that are not readily available for application by contractors;
- Attainable flow rates of at least 30 gpm;
- Appropriate design and performance data attainable through pilot testing that can be utilized by various equipment vendors; and
- Ease of operation and maintenance.

3 Technology Evaluation

Groundwater and NAPL at sites contaminated by wood-treating chemicals are remediated by applying various treatment processes to remove organic and inorganic compounds. Typically, the system contains three steps: pre-treatment, primary treatment, and polishing treatment. Pre-treatment entails physical separation of NAPLs from the water. Primary treatment removes the bulk of the dissolved contaminants from the water phase. Polishing treatment adjusts the water quality to ensure compliance with discharge requirements. Polishing treatment also provides a safety factor in the event of a failure in the primary treatment step.

Physical separation as pre-treatment includes various actions such as positive displacement pumping to reduce emulsification, settling tanks to facilitate phase separation, use of oil/water separators, absorption utilizing clay-based materials, and dissolve air floatation. NAPLs generated by the pre-treatment step are typically transported off-site for incineration or stabilization with lime or cement, depending on the appropriate Resource Conservation and Recovery Act (RCRA) hazardous waste classification. All of these pre-treatment actions are currently being conducted and evaluated at the site. Selection of the most appropriate options will be made prior to initiating final design of the groundwater enhancements.

Primary treatment options for contaminants found at wood-treating sites include air stripping, filtration and absorption, ultraviolet and chemical oxidation, biological treatment, and membrane separation (reverse osmosis). These processes are typically designed to remove at least 80%, possibly as much as 95%, of the dissolved contaminants. Each process has unique characteristics that limit its application to sites that contain certain conditions. Each process can be partially successful at any site containing wood-treating contaminants; however, one process is usually more efficient and cost effective than all of the others. An evaluation of these processes with respect to the known McCormick & Baxter site characteristics is provided in the following sections. This evaluation forms the basis for selection of a process for pilot study.

Polishing treatment can encompass many different treatment techniques. The discharge requirements and criteria significantly influence the type of polishing treatment that is utilized. The most typical techniques utilize filtration and absorption technologies; specifically, GAC for organic compounds and ion exchange for inorganic compounds. GAC is currently in use at the McCormick & Baxter site and likely will be selected as the polishing process for the organic component in the final system. In accordance with DEQ's recent approval, E & E will install ion

exchange units into the existing treatment systems this year. E & E will operate these units for at least 1 year to confirm their applicability for the final treatment system. E & E will document the selection, installation, and testing procedures and submit a technical memorandum to DEQ. The results of the testing will be presented to DEQ in subsequent quarterly reports.

The following sections present a description and evaluation of the primary treatment options for the McCormick & Baxter site. The rationale for the selection of one technology to be pilot tested also is provided.

3.1 Air Stripping

The air-stripping treatment system operates by pumping contaminated water to the top of a tower, where it is distributed over a bed of packing material. The packing provides a large, wetted surface area for contact between the contaminants and air. Air is introduced (through a blower) below the packing material and flows up through the tower in a counter-current to the contaminated water. Phase transfer of the contaminants occurs from liquid to vapor. The contaminant-laden air is then typically passed through a GAC filter unit to adsorb the contaminants, or discharged to the atmosphere without further treatment.

Air-stripping towers designs have become standardized and are available from a variety of manufacturers. Air-stripping has gained widespread acceptance as a viable and economical method for removing volatile organic compounds (VOCs) from groundwater and has been used successfully in a number of high flow-rate applications. Air stripping, however, has been shown to be less effective at removing heavy or highly soluble organics such as PAHs. As discussed in Section 2.3, these compounds represent the bulk of the dissolved organic contaminants at the McCormick & Baxter site. Given the site COCs, it is likely that significant additional treatment would be necessary to remove these compound. However, although operation and maintenance costs for a stripper are generally low, the costs associated with additional treatment could be substantial. Moreover, air stripping was eliminated from further consideration in the Revised Feasibility Study (PTI 1995).

3.2 Granulated Activated Carbon Adsorption

Treatment of contaminated water by GAC employs an adsorption process in which the contaminants in solution are attached to, and held by, a porous carbon skeleton with a large surface area per unit volume. The imbalance of forces in the pore walls of the carbon allow the contaminant to attach and concentrate via either chemical bonding or van der Waals attraction.

Once adsorption has occurred, the molecular forces in the pore walls stabilize. For further adsorption to occur, the spent carbon must be regenerated.

GAC adsorption is an effective and reliable treatment process for removing low-solubility organics over a broad concentration. GAC adsorption has successfully removed PAHs, other polar organic compounds, PCPs, nonhalogenated aromatics, dioxins, furans, and some nonvolatile and volatile metals from water at wood-preserving sites (EPA 1992). Depending on the groundwater characteristics, carbon adsorption can be used as a primary treatment process or as a polishing treatment to remove recalcitrant constituents if another primary treatment process is selected (i.e., air stripping, biological, ultraviolet). In determining whether GAC is an appropriate primary treatment process, consideration must be taken regarding operation and maintenance (O & M) costs associated with the regeneration or disposal and replacement of spent carbon. Given the elevated concentrations of PCPs and PAHs in the groundwater at the site, it is likely that GAC would be quickly spent, requiring frequent regeneration, or very large quantities of GAC would be needed to reduce the regeneration cycles. As such, maintenance costs for activated carbon would likely be high unless treatment of the waste stream by other means is employed to remove the majority of the contaminants prior to the adsorption process. In this case, the GAC would function as a viable polishing unit with less regeneration required and lower O & M costs.

3.3 Ultraviolet Oxidation

Ultraviolet oxidation is a destruction technology in which ultraviolet light oxidizes ions or compounds to render them nonhazardous or make them more amenable to subsequent removal. The ultraviolet rays are generated by mercury-vapor quartz lamps at a wavelength of 25 nanometers. Ultraviolet oxidation is a well-established disinfection technology for drinking water and wastewater, and enhanced ultraviolet systems often are used to treat hazardous streams. Ultraviolet oxidation primarily treats and/or destroys PCPs, nonhalogenated aromatics, PAHs, and other polar organic compounds found at wood-preserving sites (EPA 1992).

The advantages of ultraviolet oxidation include ease of automation, short retention time, no chemical handling (versus chemical oxidation), and no adverse effects from overexposure. Disadvantages lie mainly with the relatively high cost, ineffectiveness on turbid waters in which the rays cannot penetrate, and routine cleaning of biofilm build-up on the lamps. In addition, the ultraviolet oxidation process is relatively nonselective. That is, other compounds in the waste may be oxidized prior to destroying the COCs, decreasing the efficiency of the process and increasing the costs to remove the target contaminants. As a result, this treatment has limited

application to waters with large amounts of oxidizable components and is geared more as a polishing step for dilute, relatively clean, aqueous wastes.

A pilot test of ultraviolet oxidation was conducted at the Wyckoff Superfund site, located at Eagle Harbor, Washington. The Wyckoff site, a former wood-treating facility, has COCs that are similar to the McCormick & Baxter site. The results of the testing demonstrated that the operation and maintenance costs, particularly electricity costs were significant. Other operation problems were experienced such as growth of bio-film on the ultraviolet tubes that required frequent cleaning. The purpose of pilot testing ultraviolet oxidation was to determine whether this technology could replace the activated sludge biological reactor that is currently in operation at the site. The results of the tests precluded full-scale use of ultraviolet oxidation at this site.

3.4 Biological Treatment

Biological treatment of water detoxifies waste stream organic matter through microbial degradation. Biological treatment has been used since the early 1900s for the treatment of municipal wastewaters and has recently been effectively applied for the biodegradation of priority pollutants. The process has long been recognized as a highly effective, low-cost means for the destruction of organic compounds. Biodegradation offers the potential to completely mineralize (convert to inorganics, carbon dioxide, and water) organic contaminants with little or no risk to the environment (EPA 1991). A number of biological processes can treat water from wood-preserving sites. The technologies considered as part of this evaluation and discussed below include: conventional activated sludge treatment and fixed-film processes, including rotating biological contactors (RBCs) and fully submerged fixed-film systems. In addition, a combination of biological and powered activated carbon treatment (PACT) is also discussed.

3.4.1 Activated Sludge

Activated sludge treatment is a suspended growth process that introduces aqueous waste into a basin containing an aerobic culture of acclimated bacteria in a plug flow fashion. Air is usually provided through porous diffusers. The suspended bacterial culture transforms organics into cell constituents, other organics, carbon dioxide, and water. The flow usually passes to a clarifier, from the bottom of which the solids are returned to the aeration basin. The returned solids are subsequently mixed with the incoming waste stream and passed again through the basin. Activated sludge processes have proven effective in removing soluble biodegradable contaminants from groundwater; however, experience has shown the process to be operator-intensive. Because the plug flow regime offers little dilution of the incoming flow, the process is

sensitive to variations in influent characteristics (shock loads) and operating conditions. As such, continuous monitoring and adjustment must be conducted by site personnel, which results in high operating costs. Additional operating problems include the inability to maintain the desired sludge age. Sludge may be lost from the clarifier due to bulking or floating, even when the clarifier is properly designed for solids loading.

3.4.2 Rotating Biological Contactors

Rotating biological contactors utilize an attached growth process (unlike activated sludge, which uses suspended growth) in which bacterial solids are accumulated on a solid medium to maintain a large population. An RBC system consist of a basin or trough containing large plastic discs mounted on rotating shafts (driven by electric motors). As the discs slowly rotate, contaminated influent is passed through the basin at levels below the rotating axes of the discs, thereby exposing wastewater to the biological growth and enabling degradation. The rotating motion of the discs allows alternate exposure of the bacteria-enriched discs from wastewater to ambient air, providing an oxygen source for biological growth. An RBC can handle significant flow variations and high organic shock loads, and its modular construction can provide flexibility to meet increased or decreased treatment needs. An RBC also generates nonhazardous sludge. With increased thickness of the biological layer, the interior organisms become oxygen and nutrient deprived. Eventually these cells die and lyse, breaking the contact between the support medium and the slime layer. When enough cells have lysed, the slime layer will slough off and be transported to the waste flow to be subsequently removed via a clarifier. Reported problems with RBCs include shaft imbalance and/or overload caused by heavy or unbalanced growth leading to mechanical equipment failures (motor, shaft, and bearing), resulting in failure of the process. This problem is reportedly worse at low operating ambient temperatures. Spinning the shafts at higher speeds will help minimize the unbalanced growth by thinning the bio-films, but substantial increases in energy costs will result. In addition, experience has shown maintenance of ideal aerobic conditions for microbial growth to be difficult, resulting in inefficiency and potential treatment failure (McGhee 1991).

3.4.3 Fully Submerged Fixed Film

Fully submerged fixed-film treatment utilizes a relatively porous bacterial support medium, such as rock or formed plastic shapes, with a high surface area-to-volume ratio. Unlike the RBC, this medium is continuously submerged in the wastewater and oxygen is provided via diffused air (aeration). In addition, a concentrated inorganic nutrient solution may be added to the reactor to

maintain required concentrations of nitrogen and phosphorous. Fixed-film biological treatment systems are proven capable of destroying pollutants commonly found at wood-treating facilities including PCP and other phenolics, base/neutral extractables, halogenated hydrocarbons, gasoline components (benzene, tuolene, ethylbenzene, and xylene [BTEX]), and oxygenated solvents (EPA 1991). Moreover, fixed-film systems are currently in full-scale operation at several wood-preserving waste sites across the country with successful removal efficiencies at flow rates of at least 30 gpm. Because of the high bacteria-to-water surface area available, this treatment process is less susceptible to variations in waste characteristics and shock loading. A submerged fixed-film bioreactor also produces sludge consisting of excess sloughed biomass. However, because of the high bacteria-to-water surface area, the system allows for long cell retention time, lowering generation of lysed cells. The major operational problems with the submerged fixed-film system are associated with cold weather operation. Temperatures near freezing may cause partial plugging of the filter medium and over-loading of the remaining open area. In addition, since it is recognized that biological activity is dependent on temperature, it is beneficial to maintain a reactor temperature near 70°F. If air or groundwater temperatures are significantly lower, heat input would be required to sustain sufficient microbial growth to maintain process efficiency and, consequently, would increase operation costs. It should be noted, however, that this would also be the case for the other biological treatment processes considered.

3.4.4 Powdered Activated Carbon Treatment

The PACT process was developed and patented by Zimpro Passavant Environmental Systems, Inc., of Rothschild, Wisconsin, and employs a combination of two techniques: microbial degradation of organics and adsorption of nonbiodegradables or refractory organics. The process involves the addition of powdered activated carbon to biologically activated sludge in an aeration tank. Following aeration, solids are separated from the wastewater in a clarifier. This process has an application in cases when activated carbon treatment is considered. It is suitable for the removal of volatile organics, acid-extractable compounds, base-neutral extractables, and various metals. Approximately 100 full-scale PACT systems have been installed for treating industrial process waste (from organic chemical, pesticide, petrochemical, pharmaceutical, and textile manufacturers), landfill leachate, surface runoff, and groundwater contaminated with VOCs. The system, however, has yet to achieve full-scale operation at a wood-preserving waste site. As with GAC, the process generates spent activated carbon as well as sludge from the biological process that must be removed, dewatered (filter press), and

disposed, which together result in high operation and maintenance costs. Furthermore, the carbon inventory must be continuously monitored and maintained by addition of virgin carbon as needed. In addition, capital costs are substantially higher than for the GAC and other biological treatment units considered.

3.5 Other Treatment Technologies

Other primary treatment technologies considered include chemical oxidation, membrane separation, and dehalogenation. Like ultraviolet oxidation, the chemical oxidation process oxidizes ions or compounds to render them nonhazardous or to make them more amenable to subsequent removal. However, instead of using ultraviolet rays, chemicals such as hydrogen peroxide or chlorine dioxide are added to the reactor as the oxidant. This process effectively destroys the constituents found at wood-preserving sites, but at a high cost. Chemical oxidants are relatively nonselective and may oxidize other nontarget compounds before destroying the COCs. As such, increased quantities of chemical oxidants and higher retention times may be required to obtain cleanup objectives, resulting in elevated operation costs. This process is most useful as a polishing step for dilute, relatively clean, aqueous wastes (EPA 1992).

Membrane separation techniques such as reverse osmosis separate the chemical constituents from water and concentrate them, making reclamation possible. This technology can be used to treat groundwater contaminated with PCP, heterocyclics, simple nonhalogenated aromatics, PAHs, and other polar organics (EPA 1992). Membrane separation, however, is extremely sensitive to clogging with fines, and overpressure can often rupture the fragile membranes.

Dehalogenation uses chemical reagents to remove halogens from halogenated molecules, to break apart chlorinated molecules, or to change the molecular structure of the molecule. The process generally uses metallic sodium to strip the halogen away from constituents and form a sodium salt that may require further treatment prior to disposal. Most dehalogenation research has centered on the detoxification of polychlorinated biphenyls (PCBs, analogous to PCP) and applies to many other halogenated organic molecules, such as chlorinated pesticides and dioxins (EPA 1992). This process, however, lacks full-scale implementation and data, thereby reducing its viability for use as the primary treatment system.

3.6 Technology Selection

A number of processes have been considered for use as the primary treatment system for the contaminated groundwater encountered at the McCormick and Baxter site. E & E utilized the following criteria to determine which process would be most appropriate for pilot testing:

- Ability to efficiently remove the COCs;
- Successful full-scale application at former wood-treating sites;
- No patented or proprietary technologies that are not readily available for application by contractors;
- Attainable flow rates of at least 30 gpm;
- Appropriate design and performance data attainable through pilot testing that can be utilized by various equipment vendors; and
- Ease of operation and maintenance.

All factors considered, biological treatment has been chosen as the most appropriate remediation technology to achieve clean-up objectives.

Biological treatment has been extensively used for full-scale primary treatment of contaminated groundwater at other wood-preserving waste sites throughout the United States, successfully removing PCP and PAHs from the wastestream. Air stripping has been shown to be incapable of removing such soluble, heavy organics. GAC and ultraviolet/chemical oxidation processes are technically capable of removing these contaminants but would likely sustain elevated operation and maintenance costs. Given the expected contaminant loading, GAC would require frequent carbon regeneration, and because of ultraviolet/chemical oxidation's nonselective nature, it is likely this process would also lack the removal and cost efficiency desired.

Furthermore, biological treatment allows for the complete conversion (mineralization) of the organics to carbon dioxide and water, whereas GAC transfers the contaminants to the adsorbent, air strippers transfer the contaminants to the atmosphere, membrane separation concentrates the contaminants, and oxidation often does not achieve the desired complete conversion (EPA 1992). As a result, residues/emissions generated from these other systems may require additional treatment to ensure proper disposal, resulting in additional O & M costs. In addition, biological treatment has proven efficient in removing organics contributing to the

biochemical oxygen demand (BOD) of the wastewater, rendering the effluent more suitable for discharge and reducing the cost of carbon usage if GAC is used as post treatment (polishing).

The biological treatment technologies considered include conventional activated sludge, RBC, fully submerged fixed film, and PACT. The fully submerged fixed-film process has been selected for use as the biological treatment system to be pilot tested for treatment of the contaminated groundwater at the site.

A number of fully submerged fixed-film systems are currently in full-scale operation at other wood-preserving waste sites across the country and have achieved success in reducing contaminant concentrations to target levels at operating flow rates of at least 30 gpm. Both RBC and PACT systems have yet to attain full-scale operation at similar sites. In addition, because PACT systems use proprietary and patented technology and has limited contractor operational availability, it was eliminated from consideration. Conventional activated sludge has been employed at wood-preserving waste sites, with mixed results. It has been reported that fluctuations in the influent loading have caused problems in sustaining sufficient biomass population. Fully submerged fixed-film systems are less likely to be affected by loading fluctuations due to the high bacteria-to-water surface area available.

Additional advantages of fully submerged fixed-film systems include ease of operation and maintenance. Activated sludge systems require continuous monitoring of influent characteristics to prevent shock loading as well as monitoring and maintenance of the sludge age to achieve desired biomass populations. PACT systems experience similar operational difficulties as well as carbon inventory monitoring and maintenance, and RBC systems reportedly sustain mechanical equipment failures. Furthermore, all the aforementioned monitoring and maintenance constraints result in operator-intensive functionality and elevated operation costs. Operation and design information obtained during pilot testing of fully submerged fixed-film systems are applicable to various vendors of such equipment.

4 Toxicity and Pilot Treatment Tests

To evaluate submerged fixed-film biological treatment for use as the primary treatment system for the groundwater at McCormick & Baxter, a two-step process will be conducted consisting of a limited toxicity test and a pilot treatment test.

The objective of the toxicity test will be to validate the general approach of the biological remediation technique for treating the site-specific COCs. Specifically, the aim of the toxicity test is to identify an existing bacterial culture capable of consuming site contaminants, to identify any possible toxic effect the groundwater may have on the microorganisms, and to ensure successful operation of subsequent pilot-scale tests.

On successful completion of the toxicity test, a pilot treatment test will be conducted at a larger scale in the field. This pilot test will focus on collecting data for the design of a full-scale biological treatment system. The pilot test will be used to determine the number, type, and size of reactors to optimize removal efficiencies, flow rates, residence time, recirculation rates, air flow rates, nutrient addition requirements, pH optimization and control, temperature optimization and control, and cost estimates for construction and O & M of the full-scale system.

To complete the aforementioned tasks, E & E will employ two subcontractors: a fixed-film bioreactor vendor and a separate confirmation laboratory for confirmation analysis of the pilot water treatment process. The bioreactor vendor will be responsible for conducting both the toxicity and pilot-scale tests; the confirmation laboratory will be employed to assist in validation of the bioreactor vendor results. E & E will prepare two subcontractor scopes of work for the procurement of the subcontracted services. Information detailing the procurement of these services is included in Section 4.6.

4.1 Toxicity Test

4.1.1 Bioreactor Vendor Requirements

As part of the bid process for subcontracting a bioreactor vendor to conduct the pilot-scale test, the vendor will be required to conduct a limited toxicity test. E & E will submit a representative groundwater sample (obtained from Tank 1 of the current pilot water treatment system) to the vendor (volume to be determined by vendor) for their use in conducting their toxicity tests. Due to vendor technology and process variation, E & E has not specified the toxicity test

procedure to be used by each vendor. The toxicity tests will be vendor-specific, used to demonstrate and ensure successful operation of subsequent pilot-scale testing. However, E & E will require the vendor to document oxygen uptake measurements as a measure of microbial growth for all test conditions. It is anticipated that other possible indicator parameters will include analyses of PAHs, PCP, BOD, chemical oxygen demand (COD), and total organic carbon (TOC). E & E will require the vendor to follow the analytical protocol provided in Sections 4.3 through 4.5 and Sections 5 through 7. In addition, for quality assurance and quality control (QA/QC), positive and negative controls will be required to be performed simultaneously. Positive control will be conducted using a fortified organic chemical and nutrient solution in proportions that are known to sustain ideal microbial growth; and negative control will utilize a 0.5% copper sulfate solution that inactivates microbial enzymes and effectively inhibits microbial growth.

On completion of the toxicity testing, the vendor will submit a summary report documenting all tests conducted including specific laboratory procedures, the results of the tests, and vendor conclusions on the viability of implementing a pilot-scale test in the field.

4.1.2 E & E Personnel Requirements

E & E will be responsible for supplying the vendor with the representative groundwater sample, at an amount to be specified by the vendor. For QA/QC, E & E will also obtain a duplicate sample from the same groundwater source, which will be analyzed by a subcontracted laboratory for PAHs, PCP, BOD, COD, TOC, total arsenic, total chromium, total copper, and total zinc. All sampling and analysis will be conducted in accordance with the protocol described in Sections 4.3 through 4.5 and Sections 5 through 7.

On vendor completion of the toxicity test and submission of the summary report, E & E and DEQ will review and evaluate the test results. Successful completion of the toxicity study will demonstrate lack of inherent microbial toxicity and permit advancement to the next stage, the pilot treatment test. If evidence of microbial toxicity is revealed, E & E will evaluate other groundwater treatment technologies.

4.2 Pilot Test

4.2.1 Bioreactor Vendor Requirements

On successful completion of the toxicity test, the subcontracted vendor will provide and operate a pilot-scale fully submerged fixed-film biological treatment system.

Prior to mobilization of the process equipment to the site, E & E will require the vendor to submit a work plan. The work plan will provide detailed engineering information and specifications, including shop drawings of the process equipment; process layout; installation of the equipment; ancillary construction, start-up, and O & M services; and QA/QC techniques. In addition, the vendor will provide all supplies and equipment necessary during the construction, start-up, and operational phases of the pilot test. This includes, but is not limited to, the placement of process equipment, plumbing and piping, electrical connections, and auxiliary equipment; and providing all labor necessary to install and operate the treatment system.

Once the vendor's work plan is approved by E & E and DEQ, the vendor will mobilize all equipment to the site. The system is to be installed in the shop building and connected to the existing water treatment system, which is currently treating groundwater from the TFA. Raw water from Tank 1 will be split between the DAF and the pilot bioreactor. Treated water from the pilot biological treatment system will be conveyed through the existing GAC units prior to being discharged to the Willamette River through Outfall 2. The pilot test is expected to run for 4 months—2 weeks for mobilization/construction and system start-up, 3 months for system testing, and 2 weeks for demobilization and system shutdown. A minimum of three and maximum of five retention times will be tested during the 3-month testing period by adjustment of the flow rate. From these experimental tests, a series of removal efficiencies versus retention time curves for all indicator contaminants will be generated to assist in the design of the full-scale treatment system. At a minimum, the bioreactor will be equipped with ports for sampling influent and effluent waste streams. Sludge generated from the system must also be accessible for sampling. The vendor will provide trained personnel to operate and maintain the bioremediation pilot system during regular work hours and off-hours, as required by operational objectives and/or emergencies, during the 4-month period.

The vendor will operate the groundwater treatment system in a batch mode during the start-up period to promote the growth of the microorganisms to site conditions and to build up the population in the bioreactor. During this phase, nutrients, pH, aeration rate, and bioreactor temperature will be adjusted to optimize microbial growth/contaminant degradation. All adjustments will be documented by the vendor. Throughout the start-up phase of the pilot study, the indicator contaminant concentrations (PAHs, PCP) in the batch mode will be monitored closely until the concentrations stabilize, at which time a continuous flow mode will be initiated. If the bioreactor does not acclimate within 1 month, E & E will meet with ODEQ to discuss contingencies.

Throughout the continuous flow mode, the system will be operational 24 hours a day, 7 days a week. During the initial stages of the continuous flow mode, the vendor operations personnel, in concurrence with E & E personnel, will monitor and document indicator compound concentrations daily or at the discretion of an E & E site engineer until conditions reach steady state. Steady-state conditions will be reached when a change in the bioreactor effluent target contaminant concentrations (PAHs, PCP) is within 10% from the average of the three previous sampling events (given the influent level of the target contaminants has not risen more than 10% from the three previous sampling periods). When the vendor and E & E concur that the system has reached steady-state, a comprehensive laboratory analysis of the system (influent and effluent) will be conducted three times during a 1-week steady-state operation period. In addition, sludge generated from the biotreatment system will be sampled during the third (final) event of the week. All vendor samples (influent, effluent, and sludge) will be analyzed in accordance with the analytical requirements defined in the vendor's work plan. Organic vapor analysis will also be conducted during the third event to determine the amount of organic volatilization that occurred in the bioreactor. All sampling and analysis procedures will adhere to the protocol set forth in Sections 4.3 through 4.5 and Sections 5 through 7.

After completing steady-state analysis of the first flow rate, a minimum of two additional steady-state detention times will be tested. No more than a total of five detention times will be tested. This will be achieved through adjustment of the system flow-through rate by vendor personnel to levels determined by E & E personnel, as site conditions warrant. For each additional flow rate/detention time, the same procedures (steady-state validation phase with daily sampling and steady-state comprehensive sampling for 1 week) will be repeated.

During and after operation of the bioremediation pilot test, all sludges generated by the system will be placed into the existing on-site sludge tank for future disposal.

After all flow rate tests have been completed as determined by E & E personnel, the vendor will initiate the demobilization process. All process equipment, piping, electrical equipment, and auxiliary equipment will be decommissioned and removed from the site, and the vendor will be responsible for ensuring that the site is returned to its original (pre-construction) condition.

4.2.1.1 Vendor Reporting Requirements

The vendor will provide E & E with weekly status reports that will include a description of events that occurred during the previous 7 calendar days, a description of proposed events for the subsequent 7 calendar days, and a copy of all chemical and physical data collected from the

system. The weekly status report will be submitted to E & E personnel by 12:00 p.m. (Pacific time) on each Thursday for the entirety of the project.

Within 3 weeks following completion of the pilot test, the vendor will submit a report to E & E that will include:

- Detailed engineering information and specifications, including detailed shop drawings indicating all piping, instrumentation, and equipment used to conduct the test (including any field modifications);
- A summary of system operating conditions including flow rates, residence time, recirculation rates, air flow rates, nutrient feed rates, sludge generation rates, inoculation requirements, and operating temperatures;
- Influent and effluent characteristics of recovered and treated water such as pH, conductivity, temperature, and contaminant concentrations;
- A scaled-up design with proposed system operation rates and a proposed process schematic; and
- Cost estimates (capital and O & M) for construction and operation of the full-scale groundwater treatment system.

4.2.2 E & E Personnel Requirements

Prior to mobilization or installation of the pilot-scale biological treatment system, E & E and DEQ will review the vendor's work plan as described in Section 4.2.1. On DEQ's approval of the work plan, E & E will coordinate mobilization, installation, start-up, and operation procedures with the vendor. It is anticipated that during the 4-month installation, start-up, and operational phases of the pilot test, an E & E engineer will be available on site during regular work hours and on-call during off hours to oversee operations, collect and analyze samples, and make changes to system flow rates.

It is the responsibility of E & E personnel to maintain extraction well operation to ensure sufficient flow of contaminated groundwater to the pilot system. During the pilot test start-up and operational phases prior to steady-state conditions, an E & E site engineer will conduct daily field sampling and analysis of the system influent and effluent. Analysis will be performed using field test kits to monitor concentrations of the indicator contaminants (PAHs, PCP). This field testing will assist in the verification of the vendor's analytical results and to confirm the emergence of steady-state conditions for each flow rate. During vendor sampling events, samples will be collected by E & E at the same time as those taken by the vendor, and all

sampling and analysis will conform to the analytical protocol set forth in Sections 4.3 through 4.5 and Sections 5 through 7 of this report.

Once steady-state conditions for each flow rate are determined through field test analysis, verification analysis will be conducted for 1 week. Split samples will be taken of the influent and effluent three times during the week and analyzed at E & E's subcontracted laboratory for PAHs, PCP, BOD, COD, and TOC. Additional metal analyses (total arsenic, total chromium, total copper, and total zinc) will be conducted during the third (final) event of the week. Results of the laboratory analysis for PAHs and PCP will be compared to those acquired in the field via the field test kits for verification of the field test kit analyses and for verification of the vendor results. In addition, sludge generated from the biotreatment system will be sampled during the third event of the week and analyzed at the subcontracted laboratory for PAHs, PCP, BOD, COD, TOC, (total arsenic, total chromium, total copper, and total zinc. Organic vapor will also be sampled by E & E and analyzed by the subcontracted laboratory during the third event to determine the amount of volatilization that occurred in the bioreactor.

E & E will require the subcontracted laboratory to perform 24-hour turnaround analyses for each steady-state sampling event during the week, and all laboratory analyses will conform to the protocol set forth in Sections 4.3 through 4.5 and Sections 5 through 7 of this report.

Field parameter analysis will also be required during all sampling events (start-up and steady-state). Each sample will be analyzed for pH, specific conductivity, and temperature using a water quality field instrument and recorded in a field log book. In addition, any observable physical characteristics (e.g., color, sheen, turbidity) will be recorded for each sample.

4.3 Sample Collection Methods and Analyses

4.3.1 Water Samples - Subcontracted Laboratory

4.3.1.1 Toxicity Testing

E & E proposes to collect water samples from Tank 1 of the existing pilot treatment system for submission to each vendor for toxicity testing. Samples from the same source will also be collected and submitted to E & E's subcontracted laboratory as part of the toxicity testing QA/QC. To ensure the homogeneity of samples submitted to each vendor and the subcontracted laboratory, groundwater from Tank 1 will be gravity drained to a clean Department of Transportation (DOT) 17E/17H 55-gallon drum. The quantity drained will depend on each vendor's required sample volume for toxicity testing. Samples will be extracted from the drum with a dedicated sampling device (e.g., polyethylene dipper), then transferred to the vendor-specific sample containers. Samples to be analyzed by E & E's subcontracted laboratory for toxicity

testing QA/QC will follow the protocol set forth in Table 4-1. Any water remaining in the 55-gallon drum will be returned back into Tank 1 to be treated by the existing DAF treatment system.

4.3.1.2 Pilot Testing

E & E proposes to collect influent and effluent water samples from the submerged fixed-film biological pilot treatment test system for verification of steady-state conditions and evaluation of the system's removal efficiencies. E & E will collect samples during normal operating days after the system has been operating under specified conditions for approximately 2 to 3 hours. During vendor sampling events, samples will be collected by E & E at the same time as those taken by the vendor. Samples will be collected from the influent and effluent sample ports. Each sample port (influent and effluent) will be connected to dedicated Teflon tubing from which the samples will be directly collected. Prior to each sampling event, each port will be purged for a minimum of 10 seconds. Purge water will be containerized in DOT 17E/17H 55-gallon drums and returned to the pilot system for treatment. Organic samples will be collected first, followed by inorganic samples. All water samples are to be submitted to the E & E subcontracted laboratory for analysis. Table 4-1 lists the sample collection summary detaili ng analytical parameters, description of sample containers, sample preservation, holding times, and QC samples. E & E will use sample containers provided by the subcontracted laboratory. Samples will be delivered to the subcontracted laboratory using chain-of-custody and handling procedures outlined in Section 6.

4.3.2 Water Samples - Field Test Kits

Ohmicron Rapid Assay® field test kits will be used by E & E personnel for screening PAHs and PCP concentrations by immunoassay to determine the arrival of steady-state conditions for each test flow rate. E & E will collect influent and effluent samples. During vendor sampling events, E & E will collect samples at the same time as the vendor. Samples will be collected from the influent and effluent sample ports via attached dedicated Teflon tubing. Prior to each sampling event, the port will be purged as described in Section 4.3.1.2. Field test kit analysis will be performed in accordance with the test kit manufacturer's instructions and the protocol set forth in Table 4-1.

TABLE 4-1

SAMPLE COLLECTION SUMMARY BY SAMPLE TYPE
MCCORMICK & BAXTER CREOSOTING COMPANY
PORTLAND PLAN
PORTLAND, OREGON

Number of Samples	Analytical Parameters and Methods	Type of Containment	Sample Preservation	Technical Holding Time	Quality Control Samples
Water - Subcontract Laboratory					
22	PCP and PAHs SW-846 EPA Method 8270	1 L, glass teflon-lined lid	4°C ± 2°C	7 days from collection to extraction; 40 days from extraction to analysis	1 MS/MSD and 1 duplicate
4	Total copper, total zinc EPA-846 Method 200.7	1 L, polyethylene bottle with teflon lined lid	HNO_3 to pH ≤ 2	6 months	1 MS and 1 duplicate
4	Total aresenic, total chromium EPA-846 Method 200.8	1 L, polyethylene bottle with teflon lined lid	HNO_3 to pH ≤ 2	6 months	1 MS and 1 duplicate
22	BOD EPA Method 405.1	1 L, polyethylene bottle with teflon-lined lid	4°C ± 2°C	48 hours	1 duplicate
22	COD - EPA Method 410.4 TOC - EPA Method 415.1	250 ml, glass teflon-lined lid	HCl or H_2S0_4 to pH <2 and 4°C	28 days	1 blank 1 blank
Water- Field Test Kits					
60	PCP by immunoassay EPA Method 4010A	1 L amber jar	4°C ± 2°C	7 days from collection to extraction; 7 days from extraction to analysis	1 duplicate per 20 samples
60	PAHs by immunoassay EPA Method 4035	1 L amber jar	4°C ± 2°C	7 days from collection to extraction; 7 days from extraction to analysis	1 duplicate and 1 method blank per 20 samples

Key:

- BOD - Biochemical oxygen demand
- COD - Chemical oxygen demand
- L - Liter
- ml - Milliliter
- MS/MSD - Matrix spike/matrix spike duplicate
- PAHs - Polycyclic aromatic hydrocarbons
- TOC - Total organic carbon

4.3.3 Air Samples

Organic vapor analysis will be conducted to determine the amount of organic volatilization that occurred in the bioreactor. E & E will utilize a vacuum chamber apparatus to extract air from the bioreactor into a Tedlar® bag. A pump will be used to create a vacuum around the outside of the bag which will be connected directly to the bioreactor exhaust port via dedicated Teflon tubing. The vacuum will create a pressure gradient, drawing air from the bioreactor into the sample bag. On inflation, the bag will be sealed and immediately delivered to E & E's subcontracted laboratory to ensure sample integrity.

4.4 Decontamination Procedures

The intent of field decontamination is to prevent the cross-contamination of samples, control spread of contaminants to uncontaminated areas, and to prevent chemical exposure to the sampling team.

It is anticipated that dedicated sampling devices will be used for all field sampling activities performed for toxicity and pilot-scale testing. As such, sampling device decontamination will not be required.

4.5 Investigation-Derived Waste Disposal

Investigation-derived waste (IDW) generated during toxicity and pilot testing activities is expected to include the following:

- Purge water;
- Sample port teflon tubing;
- Sludge generated from the pilot-scale bioreactor; and
- Used personal protective equipment (PPE).

After sample collection for toxicity testing, any water remaining in the 55-gallon drum will be transferred to Tank 1 and treated in the existing groundwater treatment system. During the pilot biological treatment system sampling events, purge water will be collected in 55-gallon drums and subsequently transferred to Tank 1 for system treatment. Sludge generated from the bioreactor will be transported to the existing on-site sludge tank to await off-site disposal. All used PPE and Teflon tubing used for bioreactor port sampling will be placed in plastic bags and transferred to the existing on-site PPE dumpster for periodic disposal at Hillsborough Landfill.

4.6 Contractor Procurement

4.6.1 Biological Treatment Pilot Test Subcontractor

E & E will prepare a subcontractor scope of work to describe the requirements for conducting the toxicity test and the pilot test. The complete bid package will be provided to DEQ for review prior to distribution to the bidders. E & E proposes to distribute the bid packages with a sample of the raw water from Tank 1 of the existing pilot treatment system. The bidders will be required to review the bid package and utilize the water sample for conducting their specific toxicity test as part of preparing their bid for conducting the pilot tests. The bid period will be open for approximately 6 weeks to allow sufficient time for conducting the toxicity tests, preparing a test result report, and preparing the cost proposal. The bidders will be required to conduct the toxicity tests without cost reimbursement, and no specific cost line item for the toxicity test will be presented on the subcontract price sheet. Bidders will be considered responsive bidders if they submit the results of their toxicity tests including the minimum analytical data requested by E & E, a completed subcontract price sheet, all contract required insurance certificates, and all other miscellaneous contract required forms.

E & E has proposed to conduct the toxicity test within the bid process in an attempt to equalize the differences between each vendor. E & E placed many phone calls to six principal vendors regarding the costs for toxicity tests and received a range of costs from $2,000 to $20,000. The price difference is a result of each vendors unique methods for evaluating their process against each site's contaminants and concentrations. Since each vendor has developed their own toxicity tests tailored to their process and E & E did not believe that DEQ would approve of paying each bidder's costs for conducting the tests, E & E elected to include the toxicity tests within the bid process. Including the toxicity test within the bid process also allows E & E and DEQ to have reasonable assurance that the selected vendor will be utilizing a viable treatment technique with respect to the McCormick & Baxter contaminants and concentrations.

E & E will submit the bid evaluation criteria to DEQ along with the completed bid packages to demonstrate that the evaluation criteria were clearly established prior to initiating the bid process. On receipt of the bids, E & E will review the results of the toxicity tests along with the bidders' experience and qualifications prior to reviewing the costs. First, the bidders will be ranked based of their technical results and qualifications. Bidders' costs will then be reviewed and ranked, with the lowest cost receiving the most evaluation points. The bidder with the highest combined evaluation score will be recommended to DEQ.

4.6.2 Confirmation Laboratory Subcontractor

E & E will prepare a standard laboratory subcontractor scope of work describing the analytical requirements for the project. E & E will submit the complete bid package to DEQ for approval prior to distribution to the bidders. E & E will evaluate the bids and present a recommendation to DEQ for selection of the subcontractor based on lowest cost.

5 Quality Assurance Objectives

Specific QA objectives for the analytical laboratory data collected during normal operating, maintenance, and field activities at the site are summarized in Table 5-1. The QA objectives presented in Table 5-1 are summarized in terms of precision, accuracy, representativeness, completeness, and comparability of data to be collected and analyzed during the field activities. These parameters are described below.

5.1 Precision and Accuracy

Target values for laboratory quantitation limits, method accuracy (percent spike recovery), and method precision [relative percent difference (RPD) of duplicates/replicates]. The ranges provided for the QA objectives laboratory analyses represent the overall method limits. High concentrations of target analytes and matrix interferences can preclude achievement of quantitation limits or other QC criteria.

5.2 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

For the field activities, representativeness of the data to be produced will be maximized through careful consideration of site conditions (i.e., homogeneity) and selection of sampling sites to adequately account for site variations. In the field, care will be taken in the collection of samples to ensure that they are representative of the specific area of sample collection and the sampling matrix. Within the laboratory, precautions will be taken to extract from the sample bottle an aliquot representative of the whole sample.

5.3 Comparability

Comparability expresses the confidence with which one data set can be compared to another data set. Data produced for the field activities will be comparable to other data produced

Table 5-1

SUMMARY OF LABORATORY QUALITY ASSURANCE OBJECTIVES
MCCORMICK AND BAXTER CREOSOTING COMPANY
PORTLAND PLANT
PORTLAND, OREGON

Analytical Parameter	Technique/Method	Sample Matrix	Quantitation Detection Limits	Method Accuracy (%)	Method Precision (%)	Completeness
PCP and PAHs	SW-846 EPA Method 8270	Water	0.01 mg/L	9-127	± 28 to 50	90%
PCP and PAHs	SW-846 EPA Method 8270	Air	0.01 mg/L	9-127	± 28 to 50	90%
PCP	Field Test Kit (immunoassay) EPA Method 4010A	Water	0.005 mg/L	NA	± 50	90%
PAHs	Field Test Kit (immunoassay) EPA Method 4035	Water	0.001 mg/L	NA	± 50	90%
Total arsenic, total chromium	EPA-846 Method 200.8	Water	10 µg/L	75-125	± 20	90%
Total copper, total zinc	EPA-846 Method 200.7	Water	10 µg/L	75-125	± 20	90%
BOD	Method 405.1	Water	2 mg/L	NA	± 35	90%
COD	Method 410.4	Water	3 - 900 mg/L	NA	NA	90%
TOC	Method 415.1	Water	1 mg/L	75 - 125	± 20	90%

Key:

- BOD - Biochemical oxygen demand
- COD - Chemical oxygen demand
- mg/L - Milligram per liter
- NA - Not available
- PAH - Polycyclic aromatic hydrocarbon
- PCP - Pentachlorophenol
- TOC - Total organic carbon
- µg/L - Microgram per liter

for site investigations using similar sampling techniques and the specific analytical procedures to be used for this project.

5.4 Completeness

Completeness is the measure of how the amount of valid data obtained from a measurement system compares to the expected amount. Completeness is calculated after all analytical data have been reviewed for usability and is expressed as a decimal or percent usable data (usable data divided by total possible data).

5.5 Quality Control Samples

QC samples will be collected to ensure that the specified objectives are met. These samples include matrix spike/matrix spike duplicates (MS/MSD), blind field duplicates, trip blanks, and rinsate samples. QC sample requirements are presented in the sample collection summary tables included in Section 4.

Field duplicate groundwater samples will be collected by filling sample bottles from the sampling equipment. Separate samples will be collected for field duplicate and MS/MSD analysis. All field duplicate samples will be submitted blind to the laboratory. Field precision and accuracy indicated by the analysis of duplicates will be calculated and compared to laboratory precision and accuracy for the same samples to provide a determination of overall (field plus laboratory) precision and accuracy.

Trip blanks will consist of deionized or carbon-free water in sealed sample containers. The trip blank containers will be labeled in the same manner as field samples and submitted blind to the laboratory. Trip blanks will proceed through all stages of shipping, sampling, and analysis to provide a means of assessing any possible contamination of the samples through diffusion of volatile organic contaminants and laboratory contaminant sources. One trip blank will accompany each shipment of samples for volatile organics analysis. Equipment rinsate samples will consist of the distilled water used for decontamination in the field.

The matrix spike tests sample preparation and analytical methodology. It can provide information about sample homogeneity, extent of matrix bias, or interference on analyte recovery and indicates accuracy of the method. The matrix spike duplicate is used with the matrix spike as a combination spike to the sample and duplicate to the spike.

Trip blanks consist of deionized/carbon-free water poured into sample containers prepared prior to entering the field. They will be handled like a sample and shipped to the laboratory.

6 Sample Custody and Handling

This section describes procedures for sample identification and chain-of-custody that will be used for the field activities. The purpose of these procedures is to ensure that the quality of samples is maintained during collection, transportation, storage, and analysis. All chain-of-custody requirements comply with E & E's standard operating procedures for sample handling. All sample control and chain-of-custody procedures will follow the *CLP User's Guide* (9240.0-1D, January 1991).

6.1 Sample Identification/Documentation

Sample documentation for custody purposes includes:

- Sample identification numbers;
- Sample labels;
- Custody seals;
- Chain-of-custody records/Traffic Report;
- Field logbooks;
- Sample collection forms;
- Analytical request forms; and
- Analytical records.

During the field effort, the site manager or delegate is responsible for maintaining an inventory of these sample documents. This inventory will take the form of a cross-referenced matrix of the following:

- Sample location;
- Sample identification number;
- Analyses requested and request form number(s);

- Chain-of-custody record number;
- Bottle lot numbers; and
- Air bill numbers.

Brief descriptions of the major sample identification/documentation records and forms are provided below.

6.1.1 Sample Identification

Each sample will be assigned a unique number describing the sampling location. The sample number will be recorded on a sample label, which will be affixed to the sample jar and covered with Mylar tape. This sample location number will be used by E & E to aid with data management. The sample location numbers will use the following format.

Digits	Description	Code Example
1 and 2	Location	MB = McCormick & Baxter site
3 and 4	Port Number	P1, P2, ...
5 and 6	Matrix	WA = Water SL = Sludge AR = Air
7 and 8	Sample number (in series)	01, 02, ...
Example:	MBP2WA11 - Water sample No. 11 collected from Port 2 at the McCormick and Baxter site.	

6.1.2 Sample Labels

Sample labels attached to or fixed around the sample container will be used to identify all samples collected in the field. The sample labels will be placed on bottles so as not to obscure any QA/QC lot numbers on the bottles, and sample information will be printed in a legible manner. Field identification will be sufficient to enable cross-reference with the project logbook. For chain-of-custody purposes, all QA/QC samples will be subject to exactly the same custodial procedures and documentation as site samples.

To minimize handling of sample containers, labels will be filled out prior to sample collection. The sample label will be filled out using waterproof ink and will be firmly attached

to the sample containers and protected with Mylar tape. The sample label will contain the following information:

- Sample number;
- Sample location number;
- Date and time of collection;
- Analysis required; and
- pH and preservation (when applicable).

6.1.3 Custody Seals

Custody seals are preprinted adhesive-backed seals with security slots designed to break if the seals are disturbed. Sample shipping containers (coolers, drums, cardboard boxes, etc., as appropriate) will be sealed in as many places as necessary to ensure security. Seals will be signed and dated before use. Clear strapping tape will be placed over the seals to ensure that they are not broken accidentally during shipment. On receipt at the laboratory, the custodian will check that seals on shipping containers are intact and certify this, by completing the package receipt log.

6.1.4 Chain-of-Custody Records/Traffic Reports

The chain-of-custody record will be completed as described in the *CLP User's Guide*, in conformance with the analytical Traffic Reports. The chain-of-custody record and the analytical Traffic Reports will be completed fully at least in duplicate by the field technician designated by the site manager as responsible for sample shipment to the appropriate laboratory. Information specified on the chain-of-custody record will contain the same level of detail found in the site logbook, with the exception that the on-site measurement data will not be recorded. The custody record will include, among other things, the following information:

- Name and company or organization of person collecting the samples;
- Date samples were collected;
- Type of sampling conducted (composite/grab);
- Location of sampling station (using the sample code system described in Section 7.1.1);

- Number and type of containers shipped;
- Analysis requested; and
- Signature of the person relinquishing samples to the transporter, with the date and time of transfer noted, and signature of the designated sample custodian at the receiving facility.

If samples require rapid laboratory turnaround, the person completing the chain-of-custody record will note these or similar requirements in the remarks section of the custody record.

The relinquishing individual will record all shipping data (e.g., airbill number, organization, time, and date) on the original custody record, which will be transported with the samples to the laboratory and retained in the laboratory's file. Original and duplicate custody records, together with the airbill or delivery note, constitute a complete custody record. It is the site manager's responsibility to ensure that all records are consistent and that they are made part of the permanent job file.

6.1.5 Field Logbooks/Data Forms

Field logbooks (or daily logs) and data forms are necessary to document daily activities and observations. Documentation will be sufficient to enable participants to reconstruct events that occurred during the project accurately and objectively at a later time. All daily logs will be kept in a bound notebook containing numbered pages. All entries will be made in waterproof ink, dated, and signed. No pages will be removed for any reason.

Minimum logbook content requirements are described in E & E's SOP entitled Preparation of Field Activities-Logbooks (Appendix B). If corrections are necessary, they will be made by drawing a single line through the original entry (so that the original entry is still legible) and writing the corrected entry alongside it. The correction will be initialed and dated. Corrected errors may require a footnote explaining the correction.

6.1.6 Photographs

Photographs will be taken as directed by the team leader. Documentation of a photograph is crucial to its validity as a representation of an existing situation. The following information will be noted in the project or task log concerning photographs:

- Date, time, and location photograph was taken;
- Photographer (signature);

- Weather conditions;
- Description of photograph;
- Reasons photograph was taken;
- Sequential number of the photograph and the film roll number;
- Camera lens system used; and
- Direction.

After the photographs have been developed, the information recorded in the field notebook will be transferred to the back of the photographs.

6.2 Custody Procedures

The primary objective of chain-of-custody procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. A sample is in custody if it is:

- In someone's physical possession;
- In someone's view;
- Locked up; or
- Kept in a secured area that is restricted to authorized personnel.

6.2.1 Field Custody Procedures

The following guidance will be used to ensure proper control of samples while in the field.

- As few persons as possible will handle samples.
- Coolers or boxes containing cleaned bottles will be sealed with a custody tape seal during transport to the field or while in storage prior to use. Sample bottles from unsealed coolers or boxes, or bottles that appear to have been tampered with, will not be used.
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to another person or dispatched properly under chain-of-custody rules.
- The sample collector will record sample data in the field logbook.

- The site team leader will determine whether proper custody procedures were followed during the fieldwork and decide if additional samples are required.

When transferring custody (i.e., releasing samples to a shipping agent), the following will apply.

- The coolers in which the samples are packed will be sealed and accompanied by two chain-of-custody records. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the chain-of-custody record. This record documents sample custody transfer.

- Samples will be dispatched to the laboratory for analysis with separate chain-of-custody records accompanying each shipment. Shipping containers will be sealed with custody seals for shipment to the laboratory. The method of shipment, name of courier, and other pertinent information will be entered in the chain-of-custody record.

- All shipments will be accompanied by chain-of-custody records identifying their contents. The original record will accompany the shipment. The other copies will be distributed appropriately to the site team leader and site manager.

- If sent by common carrier, a bill of lading will be used. Freight bills and bills of lading will be retained as part of the permanent documentation.

6.2.2 Laboratory Custody Procedures

A designated sample custodian at the laboratory will accept custody of the shipped samples from the carrier and enter preliminary information about the package into a package or sample receipt log, including the initials of the person delivering the package and the status of the custody seals on the coolers (i.e., broken versus unbroken). The custodian responsible for sample log-in will open the package, check the contents, and verify that the information on the chain-of-custody agrees with samples received. Pertinent information as to shipment, pickup, and courier will be entered into the chain-of-custody record. The custodian also will document the relative temperature of the cooler and the general condition of the sample containers. The custodian then will enter the project name and sample identification information into the laboratory's sample management system.

The custodian responsible for sample log-in will complete the package or sample receipt log and note any discrepancy or improper preservation. Each sample will be assigned a unique laboratory identification number and a label will be generated for each container associated with

that sample. The label allows easy tracking of samples within the laboratory every time the sample is taken or returned to sample management.

Internal custody procedures for the transfer of samples within the laboratory will be maintained in accordance with guidelines presented herein. The laboratory will maintain records to clearly document all internal transactions as well as the ultimate fate (consumption or destruction) of the sample.

6.3 Sample Handling, Packaging, and Shipping

The transportation and handling of samples must be accomplished in a manner that not only protects the integrity of the sample, but also prevents any detrimental unnecessary exposure to sample handlers due to the possible hazardous nature of samples. Regulations for packaging, marking, labeling, and shipping hazardous materials are promulgated by DOT in the Code of Federal Regulations, 49 CFR 171 through 177 and/or the International Air Transport Association (IATA) Regulations for Dangerous Goods.

6.3.1 Sample Packaging

Samples must be packaged carefully to avoid breakage or contamination and must be shipped to the laboratory at proper temperatures. The following sample package requirements will be followed.

- Sample bottle lids must never be mixed. All sample lids must stay with the original containers.
- The sample volume level can be marked by placing the tip of the label at the appropriate sample height, or by using a grease pencil. This will assist the laboratory in determining whether any leakage occurred during shipment. The label should not cover any bottle preparation QA/QC lot numbers.
- All sample bottles will be placed in a plastic bag to minimize leakage in the event a bottle breaks during shipment.
- The samples will be cooled by placing ice in sealed plastic bags. Ice is not to be used as a substitute for packing materials.
- Any remaining space in the sample shipping container should be filled with inert packing material. Under no circumstances should material such as sawdust, newspaper, sand, etc., be used.
- The custody record must be sealed in a plastic bag and placed in the shipping container. Custody seals must be affixed to the sample cooler.

6.3.2 Shipping Containers

The appropriate shipping container will be determined by DOT or IATA regulations for the anticipated level of suspected contaminants. Since the samples at the McCormick & Baxter site contain several contaminants, it is possible that several different packaging schemes may apply. In any case, the most stringent packaging scheme will be chosen.

Shipping containers are to be custody-sealed for shipment as appropriate. The custody seals will be affixed in such a way that access to the container can be gained only by breaking a seal.

Field personnel will make arrangements for transportation of samples to the laboratory. When custody is relinquished to a shipper, field personnel will telephone the laboratory sample custodian to inform him/her of the expected time of arrival of the sample shipment and to advise him/her of any time constraints on sample analysis.

6.3.3 Marking and Labeling

Suggested guidelines for marking and labeling shipping containers are presented below. In all cases, DOT or IATA regulations should be consulted for appropriate marking and labeling requirements.

- Use abbreviations only where specified.
- The words "This End Up" or "This Side Up" must be clearly printed on the top of the outer package. Upward point arrows should be placed on the sides of the package.
- After a shipping container has been sealed, two chain-of-custody seals are placed on the container, one on the front and one on the back. If the shipping container is a drum, place one seal on each side (opposite of each other) of the drum. To protect the seals from accidental damage, place clear strapping tape over them.

7 Calibration Procedures and Frequency

All instruments and equipment used during sampling and analysis will be operated, calibrated, and maintained according to the manufacturers' guidelines and recommendations, as well as criteria set forth in the applicable analytical methodology references. Operation, calibration, and maintenance will be performed by personnel properly trained in these procedures. Documentation of all routine and special maintenance and calibration information will be maintained in an appropriate logbook or reference file, and will be available on request.

8 Deliverables

Table 8-1 lists deliverables that will be prepared for the toxicity and pilot-scale tests.

Table 8-1

TOXICITY AND PILOT-SCALE TESTS DELIVERABLES
McCORMICK & BAXTER CREOSOTING COMPANY
PORTLAND PLANT
PORTLAND, OREGON

- Laboratory subcontractor scope of work
- Biological treatment test subcontractor scope of work
- E & E/subcontractor biological treatment toxicity test results and bid evaluation report
- E & E/subcontractor fully submerged fixed-film biological treatment pilot-scale test results and evaluation report

All subcontractor scopes of work will be provided to DEQ as complete bid packages. The toxicity test results and bid evaluation report will be submitted to DEQ in the form of a letter report. The pilot-scale test results and evaluation report will be submitted to DEQ in draft form initially; a final document will be submitted after receipt and incorporation of DEQ comments.

9 References

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McGhee, Terence J., 1991, *Water Supply and Sewerage*. McGraw-Hill Publishing Company.

PTI Environmental Service (PTI), 1995, *Revised Feasibility Study, McCormick & Baxter Company*, submitted to Oregon Department of Environmental Quality, September 1995.

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